DOD Rhode Island Initial Report

Aids to Navigation Team

Bristol, Rhode Island

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Introduction

Background

Nuvera was formed in April 2000 through the merger of Epyx Corporation, a wholly owned subsidiary of Arthur D. Little, Inc., of Cambridge, Massachusetts and De Nora Fuel Cells, a wholly owned subsidiary of Gruppo De Nora of Milan, Italy. The merger brought together 10 years of fuel processor technology from Epyx and 10 years of fuel cell stack technology from De Nora, as well as a wealth of knowledge, know-how, and expertise in chemical reactor design, electrochemistry, and system integration.

Fuel cell power modules convert fuel to unregulated electricity. If hydrogen is the fuel, the power module consists of a fuel cell stack and the balance of plant and control system to operate it. When running on a hydrocarbon or alcohol fuel, a fuel processor is also included. Power modules are flexible in that they can be used for multiple applications, depending on how they are integrated into a final product. Critical to the operation of a fuel cell power module is the integration between the fuel processor and the fuel cell stack. However, the interaction between the two technologies is complex and often requires extensive expertise in fuel cells, fuel processing, and systems integration.

Objective

Nuvera is to install two Avanti™ (Figure 1) fuel cell power systems (FCPS) at in the maintenance facility at the Aids to Navigation Team, U.S. Coast Guard site located in Bristol, Rhode Island. Avanti™ is Nuvera's second-generation distributed generation fuel cell system, designed to provide approximately 4kW each of baseload electricity and heat. It is a residential type PEM fuel cell. This site provides an opportunity to install systems in a high salt air atmosphere and rapidly changing climatic conditions.

Figure 1. Avanti™ Fuel Cell Power System

Site Description

The U.S. Coast Guard, Aids to Navigation Team site is located in Bristol, Rhode Island on a peninsula located between Narragansett and Mount Hope Bays. Bristol is about 12 miles southeast of Providence and 12 miles north of Newport. This unit maintains waterway navigation equipment and support of other Coast Guard units. Historical ambient temperature information,

heating degree-days, and precipitation data is shown in Table 1. The maintenance facility is the suggested location for placement of the Avanti™ units. Figure 2 shows an overhead view of the facility exhibiting the proximity to the salt water. Figure 3 shows the outside of the building that will house the units. It is used to repair equipment and fabricate metal and wooden parts for ships. Additionally, it houses an electronics repair facility and few offices. The facility is open 24 hours per day, 7 days per week, but is not used constantly. A gas fired forced hot water system is located within the maintenance building to provide heating. Several overhead heating units with fans are distributed throughout the building. Additionally, an electric water heater provides hot water to the building. The plan is to direct waste heat from the FCPS to the outdoors via an external heat exchanger, there is the potential to supply heat to the maintenance facility with the FCPS.

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Average Maximum Temperature														
	°C	2.5	3.5	7.8	13.8	19.6	24.9	27.8	27	23.5	17.8	11.6	5.1	15.4
	°F	36.5	38.3	46	56.8	67.3	76.8	82	80.6	74.3	64	52.9	41.2	59.7
Average Minimum Temperature														
	°C	-7.1	-6.1	-1.7	3.1	8.5	13.7	17.3	16.6	12.1	6.1	1.6	-4.2	5
	°F	19.2	21	28.9	37.6	47.3	56.7	63.1	61.9	53.8	43	34.9	24.4	41
Cooling Degree Days														
	°C	0	0	0	0	3	48	132	112	35	3	0	0	336
	°F	0	0	0	0	5	86	238	202	63	5	0	0	605
Heating Degree Days														
	°C	638	548	475	293	136	17	0	4	50	199	350	554	3268
	°F	1148	986	855	527	245	31	0	7	90	358	630	997	5882
Average Precipitation														
	mm	98.5	91.6	102.8	104.3	95.5	84.5	80.7	92.2	88.3	93.7	112.5	111.2	1156
	inches	3.9	3.6	4	4.1	3.8	3.3	3.2	3.6	3.5	3.7	4.4	4.4	45.5

Table 1. Historical climactic conditions.

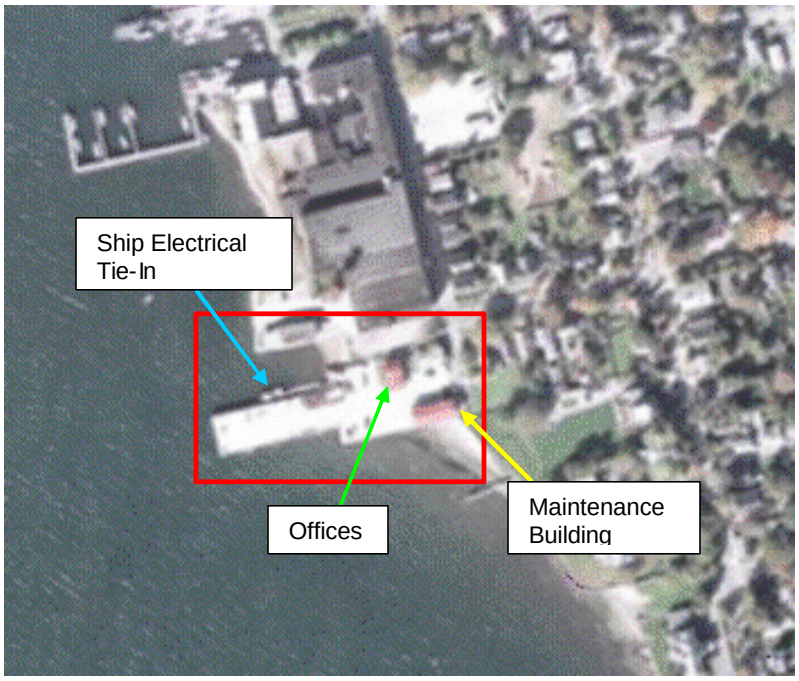

Figure 2. Aerial view of installation site.

Figure 3. Outside view of maintenance building.

Site Layout

Within the maintenance building, the section that is to house the FCPS has an area of 938 sq ft and is detailed in Figure 4. The Avanti™ units will be placed along the north wall of the maintenance bay opposite the mechanical room (shown in Figure 5) with ventilation ducted through the wall to the window located in the mechanical room. A water supply and a drain are located inside the mechanical room. Electrical connections would be required to be extended to the installation site from the east wall. An alternative site to install the units is along the east wall towards the northeast corner.

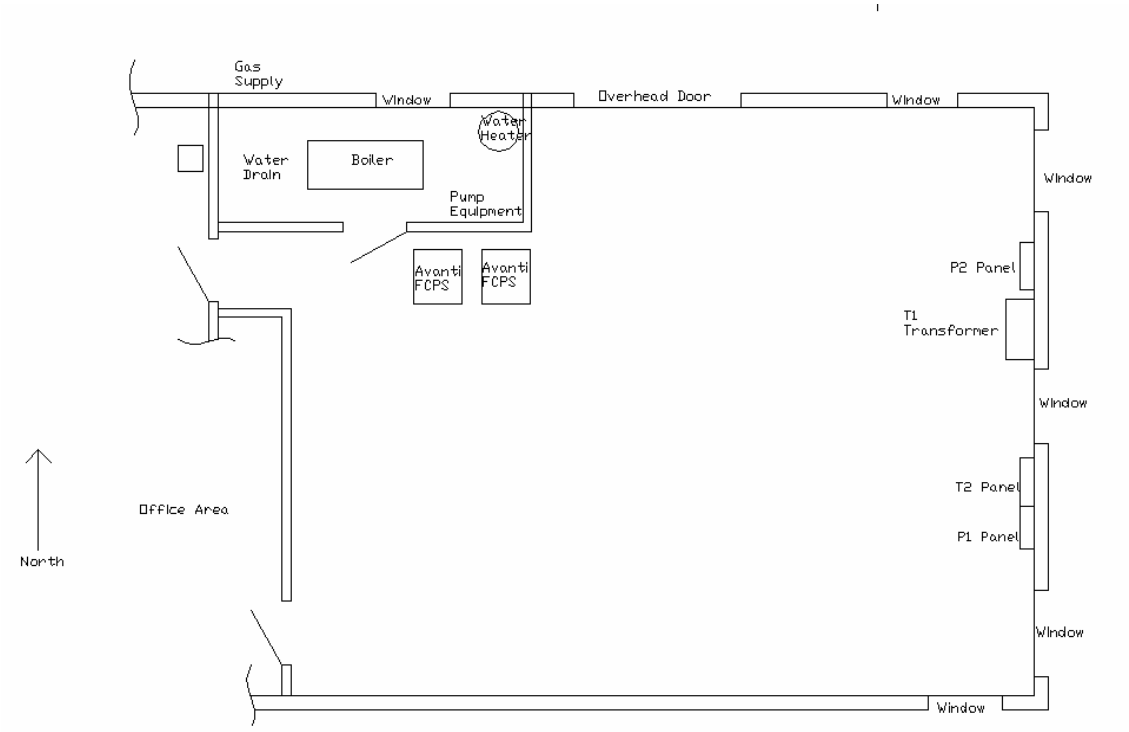

Figure 4. Installation site layout.

Figure 5. Installation site within maintenance building.

Electrical system

Inside of the maintenance shop there are two transformers shown on Figure 4 as T1 and T2. Additionally, there are two distribution panels marked as P1 and P2 on Figure 4. Both distribution panels are listed as 117/208 VAC systems. T1 is a 3 phase, 225 KVA transformer with a 480 V 270 A high voltage side and 208 V with four 120V taps rated at 625A total. T1 feeds the P2 distribution panel with a 225A main breaker switch. There are numerous open positions available in this panel for connection. T2 is a transformer that feeds P1 and a second subpanel that is incorporated into T2. This subpanel is rated at 440V and 600A, it contains 5 breakers, one connected to a welder and the other 4 supplying power to the ship power supplies located on the dock. The primary dock supply is connected to a power transformer that is used to supply power to ships at dock. The P1 distribution is marked as 117/208VAC as well and also has several open positions available. The headquarters building that is located on site is supplied by a second electrical service with a stand-alone meter.

Space Heating System

The heating system for the maintenance building is located in the mechanical room and is shown in Figure 4 as forced hot water. The system used natural gas connected to a supply outside of the north wall.

Fuel Cell Location

The proposed location to install the FCPS is shown in Figure 4, along the north wall of the maintenance bay outside of the mechanical room. This provides adequate space with water and drain available as well as ventilation through the window of the mechanical room. Electrical connection to the FCPS would require adding a disconnect switch for each system extended from

either P1 or P2. This would require 30 to 50 feet of wire. Natural gas will be supplied from the same trunk as that supplying the forced hot water system. The supply lines are capable of this additional connection. Approximately 15-20 feet of piping will be required to work around the door entering the mechanical room.

Fuel Cell Heat Dissipation

The current plan for heat dissipation from the FCPS is to install a radiator system outside of the maintenance building and not connect to the forced hot water system. The radiator systems would be placed either in front of the building on the north side, on the east side of the building, south side, or on the roof of the building. Installing the radiator units on the east or south side of the building would offer the best protection from accidental interference with vehicles or pedestrian traffic and would allow the radiators to be placed on a frame at an optimum height. Placement of the radiators on the north side of the building would require a protective barrier to keep people and vehicles from contacting them. Locating the radiators on the roof of the building would require special brackets to be constructed due to the pitched roof and would require considerable recovery efforts. This option is not recommended.

There is potential to install a radiator system inside of the building for supplemental heating of the maintenance bay. Since each room in the building has its own heat exchanger and control system for the forced hot water system, it may be possible to install a radiator with a simple control system without affecting the current heating system. The heat dissipation from the FCPS is rated at 5kW for each unit.

Fuel Cell Interfaces

The maintenance shop contains the required 208 volt power required by the fuel cell system. Feed water is available by extending existing service from a water supply inside of the mechanical room. Natural gas supply will be extended from the supply available at the boiler. A larger gas meter will be required, but the feed lines are adequate. The FCPS drain will be connected to the existing drain in the mechanical room and drain water delivered via a condensate pump.

Economic Analysis

The original proposal called for the heat of the FCPS to be dissipated to the exterior of the building, this analysis is based on that premise.

Grid connection of the FCPS will allow the electrical load of the facility to be lowered with the potential to generate revenue with allowed net metering of the facility by Narragansett Electric. Electric data were obtained for the months of March 2002 through February 2003 displayed in Table 2. This site uses natural gas supplied by New England Gas Company. Gas usage for the year 2002 was 2827 therms (2755 CCF) with a distribution charge of $0.26/therm and a fuel charge of $0.7120/therm. The total charges for the year were $735.02 for distribution and $2012.82 for fuel. The charges incurred for this meter is for space heating of the maintenance facility only since the boiler is the only appliance connected to this meter.

Bill Date	kWh Use	Net Bill	Avg. Cost/kWh	# of day	Avg. Use/ Day
3/29/2002	8000	$738.99	$0.09	28	285.7
4/29/2002	7800	$729.27	$0.09	31	251.6
5/30/2002	8100	$750.57	$0.09	32	253.1
6/28/2002	7100	$679.52	$0.10	28	253.6
7/29/2002	3600	$430.84	$0.12	30	120
8/26/2002	5800	$565.61	$0.10	29	200
9/25/2002	4600	$480.34	$0.10	32	143.8
10/25/2002	5800	$565.61	$0.10	28	207.1
11/25/2002	7300	$672.20	$0.09	30	243.3
12/31/2002	9700	$850.79	$0.09	36	269.4
1/29/2003	12100	$1,042.47	$0.09	31	390.3
2/27/2003	11600	$1,012.21	$0.09	29	400

Table 2. Site electric billing information.

Electrical energy saving were based on 90% availability for the year at an average rate of $0.0955 per kilowatt. The potential electrical energy savings for the site would be $5574 shown in the following calculations.

3.7kW * 2 systems * 8760 hours/year * 90% availability = 58342 kWh
58342 kWh * $0.0955/kWh = $5574

Gas usage would be increased as the space heating would still be required and additional supply required for the operation of the FCPS. At full power, the FCPS operates at approximately 12kW thermal input or 43 scfh. The additional fuel costs for operating 2 systems will be $7527 for the year. This is shown in the following calculations.

43 scfh / 100CCF/scfh * 2 systems * 8760 hours/year * 90% availability = 6780 CCF
6780 CCF * 1.024 therm/CCF * ($0.26/therm dist. + $0.7120/therm fuel) = $6748

The cost of placing the fuel cell units in this location will be the difference of the cost of the fuel ($6748) and the potential saving of the electrical energy usage ($5574). This cost will be approximately $1174.

With the installation of two interior heat dissipation units to apply space heating during the winter months there would be a potential savings of $1350 with an equipment cost of $600 per unit.

Conclusions

The installation of Avanti™ units in the maintenance facility at the Bristol Rhode Island Coast Guard facility provides a unique opportunity to study the effects of the high salt air installation on the FCPS. The additional cost of fuel, without cogeneration installation, is minimal compared to the learning potential offered by the site installation. Installation services are conveniently located in the facility.

The opportunity for a limited cogeneration installation remains. Configuring the system to supply heat to the maintenance bay and office area may curtail the cost of the additional fuel usage.

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